

DOCKET FILE COPY ORIGINAL  
**ORIGINAL**

RECEIVED  
**AUG 2 1996**  
FEDERAL COMMUNICATIONS COMMISSION

Before the  
FEDERAL COMMUNICATIONS COMMISSION  
Washington, D.C. 20554

In the Matter of )  
 )  
Advanced Television Systems and Their ) MM Docket No. 87-268  
Impact Upon the Existing Television )  
Broadcast Service )

To: The Commission

**REPLY COMMENTS OF PCUBE LABS**

Professional Products & Promotions, Inc.<sup>1</sup>, a Florida Small Business Corporation doing business as PCUBE Labs, hereby submits reply comments on the Fifth Further Notice of Proposed Rule Making (the "5th NPRM") in the above-captioned proceeding.

**1.0 Introduction**

In the weeks since PCUBE Labs filed comments to 5th NPRM every effort has been made to obtain copies of the numerous comments filed in this proceeding and to analyze these comments. The reply comments which follow are limited to what PCUBE Labs considers to be the most relevant issues raised in those comments. A brief summary of the key issues is included in this introduction.

---

<sup>1</sup> These comments have been prepared by Mr. Craig Birkmaier, President of PCUBE LABS, a technology consultancy dealing with the convergence of video, computer and telecommunication technologies. PCUBE has been intimately involved with the development of computer based tools for digital video editing and image composition with clients including: Avid Technologies, Scitex Digital Video, LucasFilms, Hewlett Packard, Adobe Systems and IBM. Mr. Birkmaier is actively involved in the development of new markets for visual communication products as a contributing editor to Videography and Television Broadcast magazines, and through his extensive involvement in standards work related to the convergence of video and computer technology and advanced television systems. These comments reflect the position of PCUBE Labs and Mr. Birkmaier, and do not represent any other company or individual.

*026*  
1

1.1 Throughout the ATV process there has been a consistent effort to discuss the key issues related to interoperability of the proposed ATSC standard with other components of the emerging National Information Infrastructure. Craig Birkmaier, the principal of PCUBE Labs, was a participant in the FCC Advisory Committee on Advanced Television Service (ACATS) PS/WP4 Interoperability Review; a contributor to the NIST sponsored Workshop on Advanced Digital Video in the National Information Infrastructure; a participant in the Advanced Television System Committee (ATSC) T4 Focus Group on Interlace versus Progressive Scan for Studio Production Formats; and an active participant in numerous ACATS and ATSC reviews.

1.2 A wide range of issues were raised by many individuals and organizations who filed comments to the 5th NPRM, including: The Computer Industry Coalition on Advanced Television Service (CICATS); The Coalition of Film Makers; Microsoft Corporation; Intel Corporation; William F. Schreiber; The National Cable Television Association; The Information Technology Industry Council; Branko J. Gerovac; The Consumer Federation of America and Media Access Project; The MIT Research Program on Communications Policy; Demografx; Digital Theater Systems, LP. The comments of these individuals and organizations have recently been characterized as an “eleventh hour” attempt to derail the nine year Advanced Television Process. These reply comments will describe the consistent efforts of PCUBE Labs and many other organizations to raise and discuss these issues in ACATS reviews of the proposed standard dating back to 1992.

1.3 Those who favor adoption of the proposed ATSC standard have cited the ACATS PS/WP4 Interoperability Review and the Workshop on Advanced Digital Video in the National Information Infrastructure as “endorsing” the proposed ATSC standard. As a participant and major contributor to both of these activities Mr. Birkmaier is in a knowledgeable position to comment on the findings of these review activities. It is the opinion of PCUBE Labs that the published reports of these activities *do not* support the assertions of those who favor the proposed ATSC standard. Rather, these reports provide a clear record of the issues raised consistently throughout the ATV proceedings and support the positions of those who seek to modify the proposed ATSC standard.

1.4 In Section VI item 61 of the 5th NPRM the Commission states:  
“The working party and an “interoperability review panel” also adopted a list of eleven characteristics critical to interoperability based on the needs and desires

exhibited by alternative media advocates.<sup>2</sup> ACATS believes the Grand Alliance video system adequately addresses all eleven factors.”

Numerous comments to the 5th NPRM challenged the ACATS position that the proposed ATSC standard adequately addresses the eleven factors identified by the ACATS PS/WP4 Interoperability Review. Section 2.1 of these reply comments will provide additional support for the position that several of these factors are critical for interoperability and are not adequately addressed by the proposed ATSC standard.

1.5 In Section VI item 62. Of the 5th NPRM the Commission states:

“In all, ACATS believes that the Grand Alliance plan strikes the best balance between various technical considerations and needs of different industries. It is a balance that has been endorsed by, among others, a subgroup of the Federal Government's Information Infrastructure Task Force, the 1994 NIST/ARPA Workshop on Advanced Digital Video, and the Information Technology Industry Council ("ITI").<sup>3</sup> We request comment on the level of interoperability between the ATSC DTV Standard and alternative media and on the ACATS Report's conclusion that it is adequate.”

In a letter to FCC Chairman Reed Hundt, dated July 10, 1996, Lionel S. Johns, Associate Director for Technology--Office of Science and Technology Policy, commenting on the 5th NPRM stated: “Several Groups, including the Computer Systems Policy Project (CSPP), The National Institute of Standards & Technology, and the Information Infrastructure Task Force have all conveyed their endorsement of the ATSC DTV standard. We are sympathetic to the CSPP recommendation that as HDTV evolves, an implementation plan to ensure the transition from interlace to progressive scan should be developed.”

---

<sup>2</sup> ACATS Report, Appendix I.

<sup>3</sup> ACATS Report at 16. See also Information Technology Industry Council, "Position Statement on Standards for Advanced Television," October 31, 1995, at 1-2. We note that subsequently ITI stated that the ATSC DTV Standard "will be an important part of a diverse and flexible NII" and "urges the Commission to promptly adopt and implement" it, but without the interlace options, stating that it believes "a truly interoperable ATV system will require the exclusive use of progressive scan." See Comments of the Industry Information Technology Industry Council filed in response to the Fourth Further Notice, at 2-3.

As a participant and contributor to the 1994 NIST/ARPA Workshop on Advanced Digital Video, Mr. Birkmaier is in a knowledgeable position to comment on the recommendations of this workshop. Section 2.3 of these comments analyzes the recommendations of the workshop as they relate to the issues raised in comments to the 5th NPRM.

1.6 Recently, the proposals of CICATS and others, to modify the proposed standard have been assailed as being *unproved*, *untested*, and *too late* for the formal technical reviews, which took place between the formation of the Grand Alliance in 1993 and the testing of the proposed ATSC standard in 1994-95. These comments will discuss the fact that the proposed SDTV formats were added to the standard in July of 1995; that these formats have never been subjected to the same testing as the proposed HDTV formats; and that *no provisions* were made within the ATSC selection process for the SDTV formats, or the ACATS review of the SDTV formats, to study or test alternatives proposed by other affected stakeholder communities.

1.7 In Section IV item 50 of the 5th NPRM the Commission states: "Proponents of the ATSC DTV Standard respond that the Standard was developed for terrestrial broadcasting but has incorporated significant elements to enhance compatibility with computers.<sup>4</sup> With respect to the issue of the presence of interlaced scanning in the proposed Standard, the Grand Alliance argues that, "...the Grand Alliance HDTV system emphasizes progressive scan -- five of the six HDTV formats are progressive scan, and the Advisory Committee believes that the lone interlaced format should be "migrated" to progressive as soon as improvements in digital compression and transmission technology make an over-1000 line, 60 Hz progressively scanned format achievable within a 6 MHz terrestrial channel."<sup>5</sup>

It is the opinion of PCUBE Labs that the ATSC standard, as proposed, does not adequately serve the near- and long-term markets for digital television broadcasting with affordable receivers for the mass market consumer. Instead, the proposed ATSC standard is optimized for the premium market for HDTV receivers; requiring all receivers to

---

<sup>4</sup> Letter of Stanley Baron, President, Society of Motion Picture and Television Engineers ("SMPTE"), 28 August 1995, at 2. Memo of Paul Misener, ACATS, to Fiona Branton, ITI ("Misener Memo"), August 18, 1995, at 1-2. Reply Comments of the Digital HDTV Grand Alliance, in response to the Fourth Further Notice, at 38 and 40.

<sup>5</sup> Reply Comments of the HDTV Grand Alliance, supra at 40.

decode HDTV formats would add unnecessary cost and complexity to mass market digital television receivers. Affordable DTV receivers which decimate HDTV transmissions are likely to deliver inferior quality images when compared with a progressive scan “base layer” system similar to that proposed by CICATS.

In particular, the inclusion of 2 million pixel (Mpixel) display formats in the proposed standard are inappropriate for consumer receivers (see Section 2.3 of these comments). Elimination of 2 Mpixel formats from consideration at this time, with standardization of a 480 line progressive scan “base layer” and augmentation for 1 Mpixel HDTV would make the proposed standard more affordable both for consumers and broadcasters, while simultaneously addressing the need for interoperability with NII applications.

Comments filed by CICATS, Demografx, and William Schreiber challenge the contention that it is not currently possible to encode 2 million pixel (2 Mpixel), high temporal rate (60-72 Hz) formats with adequate quality for transmission in a 6 MHz terrestrial channel. While the ability to transmit 2 Mpixel formats may be of interest at some date in the future, it is the opinion of PCUBE Labs that these formats have no place in a mass market digital broadcast standard, especially if the Commission’s goal is to encourage rapid migration to digital broadcasting.

The research of Demografx and others should provide the commission with adequate confidence that higher levels of spatial resolution can be accommodated in the proposed digital transmission channels through augmentation of a progressive scan “base layer” standard, similar to that proposed by CICATS. It should be noted that a layered approach to image encoding would still allow for the addition of two Mpixel formats through augmentation, if and when affordable 2 Mpixel displays can be delivered to consumers. This research should also cause Commissioners to question why interlaced formats are being proposed for SDTV.

1.8 It is the opinion of PCUBE Labs that the FCC *should* establish a minimal enabling standard for digital television. This standard should be modular, layered, scalable and extensible. In other words, the Commission should encourage all stakeholders to develop a “base layer” standard which will provide the certainty desired by the Commission, together with the extensibility desired by the stakeholders who have filed comments requesting modification of the proposed ATSC standard.

## **2.0 Detailed Reply Comments**

The following comments are divided into several major sections. Some of these sections include quotations from the reports which they discuss. The content of these reports is included in quotations. The comments of PCUBE Labs are indicated by the preface “Comments:”

### **2.1 FCC ACATS PS/WP4 Interoperability Review Report**

#### **2.1.1 Overview**

The ACATS PS/WP4 Interoperability Review was the most inclusive activity conducted by the FCC Advisory Committee on Advanced Television Service. This review took place in October of 1992 while the original proponent systems were being tested. PS/WP4 issued its final report in January of 1993, prior to the conclusion of technical testing of the proposed systems and the formation of the Grand Alliance, which unified many of the proposed systems into a single entity. Many stakeholder communities were represented on the PS/WP4 panel, including participants from the computer industry and television program distribution channels including cable, DBS and telephone companies.

The findings of the PS/WP4 review were available to guide the Grand Alliance and ACATS during the “technology bake-offs” in which the final parameters of the proposed ATSC standard were determined. Members of the Grand Alliance, ACATS, and the ATSC often point to this report as an endorsement of the proposed standard, however, only certain formats, of the 17 proposed, conform with the recommendations of the PS/WP4 report. Many of the formats, including those that are most likely to be used by broadcasters because of compatibility with existing NTSC and HDTV program origination infrastructures, *do not* conform with the PS/WP4 recommendations. The following sections of the *recommendations* section of the report are of particular interest to this discussion:

2.1.2 “The Interoperability Review findings point out the critical factors and features that are necessary to achieve the full benefits of ATV. All proponent systems incorporate some measure of interoperability. We endorse the Conclusions and Recommendations

from the Interoperability Review, and encourage the full suite of recommendations so that the full benefits of ATV are achieved for broadcast and non-broadcast uses.”

Comments:

While the report encouraged compliance with the full suite of recommendations, the proposed standard conforms only where it is convenient. It is noteworthy that the formats proposed by the Grand Alliance look much like those in the original individual companies that later formed the Grand Alliance. Only the 2 Mpixel formats were modified to provide support for square pixels. While this change complied with one of the PS/WP4 recommendations, it was due as much to ongoing efforts in the international broadcast community to move from 1035 to 1080 scanning lines and square pixels as to concerns about interoperability; interlace was retained in the 60 Hz field rate for this format. This can be confirmed by examining the records of the U.S. delegation to the CCIR, available from the Commerce Department, during the period from 1990-1992.

2.1.3 “Progressive Scan Transmission Format -- The traditional television industry represents the only significant use of interlace scan -- for historic technical reasons. An interoperable long-lived standard at a minimum requires the transmission signal to be progressive scan -- regardless of whether in the short term the two extreme ends of the delivery chain (cameras and displays) remain interlace with de-interlacing occurring in or near the camera before transmission and with scan reduction occurring at the display.”

Comments:

This recommendation was ignored in the 1920 x 1080 @ 60 Hz interlaced format because of concerns about coding efficiency. Additional interlaced formats were included in the proposed ATSC standard when the SDTV formats were added in July of 1995, in spite of the fact that there is no technical reason--related to coding efficiency, camera sensitivity or any other reason--to preclude the encoding of progressive scan source material in the less demanding SDTV formats.

The inclusion of interlaced SDTV formats directly contradicts the stated goal of the Grand Alliance, ACATS and ATSC to migrate to all progressive formats and encoding when technically feasible.

Support for the use of interlace in SDTV formats relates primarily to interoperability with MPEG-2 Main Profile at Main Level (MP@ML); it is the basis for the European DVB standard and several DBS and cable services now in operation in North America. MP@ML was created specifically to support the existing ITU-R601 digital video acquisition infrastructure used throughout the world for origination of NTSC and PAL broadcasts.

It would be preferable for DTV broadcast license holders to de-interlace these existing signals then encode them using a progressive scan "base layer" format, to improve image quality and accelerate the acceptance of new DTV receivers. To support interoperability DTV receivers could be designed to decode the MP@ML encoded programs carried by other service providers. It is believed that the Commission has the necessary authority to require DTV license holders to de-interlace signals prior to encoding for transmission; the marketplace would still be free to develop both interlaced and progressive scan receivers.

While MP@ML encoders are currently available to encode the video formats now used by NTSC broadcasters, these encoders are limited to processing 10.4 million pixels per second and cannot be used for the progressive scan SDTV formats included in the proposed ATSC standard. As MP@ML encoders will be used for the European DVB standard, DBS and cable services, it is expected that their cost will rapidly decline from the current \$50,000 - 70,000 price level. Due to the fact that MP@ML encoders will be the least expensive, together with the fact that they can be used with the existing NTSC broadcast infrastructure, there is a high degree of risk that local broadcasters will choose to begin DTV broadcast operations using only MP@ML compatible formats. This will do little to encourage consumers to upgrade to more capable digital receivers, although it may stimulate sales of set-top decoders.

There are no commercial encoding products available for the progressive scan SDTV formats and the HDTV formats in the proposed ATSC standard. All of these formats are contained in the MPEG-2 Main Profile @ High Level (MP@HL) which requires an encoder capable of processing 62.4 million pixels per second. Current estimates--from statements in ACATS proceedings--are that MP@HL encoders will cost in excess of \$300,000. The market for MP@HL encoders will be limited to facilities that also invest in HDTV origination equipment; testimony at the December 1996 FCC En Banc hearing on Advanced Television place the total investment for facilities to produce, encode and transmit MP@HL formats in excess of \$3 million per station.



The international MPEG-2 standard is notably lacking in the definition of a profile that would support 480 line progressive scan formats with processing requirements in the range of 20 to 25 million pixels per second--these formats were *evacuated* to the more demanding MP@HL.

Standardization of a "base layer" format similar to that proposed by CICATS would encourage the development of a new MPEG-2 profile, which would deliver much higher quality images than MP@ML, at significantly lower cost than MP@HL. If the Commission established such a goal for the U.S. DTV standard a suitable MPEG-2 profile could be developed in a relatively short period of time; no new encoding techniques need be developed, as the proposed "base layer" is simply an extension of MPEG encoding techniques that have already been verified and tested. The Commission should take note of the fact that the proposed SDTV formats were added to the standard without any formal testing as part of the U.S. ATV process; there is no reason to delay issuing DTV licenses, as the documentation of a new MPEG-2 profile could take place simultaneously with the license application period.

2.1.4 "Square Pixels (Square Sampling Grid) -- The television industry represents the only significant use of non-square pixels. (The first CRT displays used in the computer industry often used non-square pixels and interlace scan. It was quickly realized that this was not acceptable for ergonomic, picture quality, and computational needs across the variety of uses of picture material.) Square pixels are critical to sharing picture information across industries and uses."

Comments:

Prior to the addition of the SDTV formats all of the proposed HDTV formats were based on square pixels. The SDTV formats in the proposed ATSC standard incorporate not one, but three different pixel aspect ratios:

- 1:1 (square) for the 640 x 480 formats;
- 0.89:1 for the 4 x 3 aspect ratio 704 x 480 formats;
- and 0.75:1 for the anamorphic 16 x 9 aspect ratio 704 x 480 formats.

The proposed SDTV formats do not include a square pixel 16 x 9 format (e.g. 848 or 864 x 480). Mr. Birkmaier, and others who participated in the July 1995 ACATS review of

the SDTV formats, proposed that such a format be added--the proposal was voted down as it is incompatible with the 720 pixel per line limitation of MP@ML.

The CICATS "base layer" proposal is based entirely on square pixels, and it provides flexibility for any aspect ratio up to 2:1. The proposed ATSC standard does not provide the same flexibility to support multiple aspect ratios and compromises vertical resolution to a far greater extent than the CICATS proposal, when images wider than 16 x 9 are encoded.

2.1.5 "Modular Architecture and Cost Effective Range of Implementation -- There will be a wide range of devices from very low cost to highly advanced. They will vary across many features -- e.g., black & white or color, small to large display, pocket sized to wall mounted, intelligent and interactive. The inexorable advances of VLSI technology, digital signal processing and communication, display technology, etc. will rapidly bring new features and capabilities. The ATV decision needs to endure for several decades in this context of inevitable and continual advances."

Comments:

The original comments filed by PCUBE Labs to the 5th NPRM recommended a modular approach to the DTV standard. These comments are supported by the PS/WP4 report.

The commission should note the comments of CICATS, Microsoft, Intel, with respect to this subject, and in particular, the National Cable Television Association:

"While a government-imposed, well-defined standard may guarantee certainty, it will freeze technology in a rapidly changing industry and unnecessarily define commercial development of the technology. Moreover, when the marketplace settles down, standards, if necessary, will be set voluntarily without government intervention."

It is the opinion of PCUBE Labs that the FCC *should* establish a minimal enabling standard for digital television. This standard should be modular, layered, scalable and extensible. In other words, the Commission should encourage all stakeholders to develop a "base layer" standard which will provide the certainty desired by the Commission, together with the extensibility desired by the stakeholders who have filed comments requesting modification of the proposed ATSC standard.

## **2.2 Workshop on Advanced Digital Video in the National Information Infrastructure**

2.2.1 The Workshop on Advanced Digital Video in the National Information Infrastructure, hosted by the National Institute of Standards and Technology and Advanced Research Projects Agency, was held in Washington, D.C. May 10-11, 1994. Mr. Birkmaier was one of approximately 180 people who attended this workshop and a major contributor to both the Workshop and resulting report. The full report can be viewed via the World Wide Web at:

<http://www.eeel.nist.gov/advnii/>

Mr. Birkmaier's contribution to the report: A Commentary on Requirements for the Interoperation of Advanced Television with the National Information Infrastructure, is available at this web site.

Overall, the workshop proved to be a valuable forum for discussions related to the issues of harmonizing the requirements for Advanced Television--commonly referred to as Digital Television or DTV--with the requirements for a comprehensive and interoperable digital communications infrastructure--commonly referred to as the National or Global Information Infrastructure (NII/GII). It would be a rather large leap of faith, however, to conclude that the Workshop Report is in any way an endorsement of the proposed ATSC Standard.

It is important to consider the fact that Grand Alliance, and video equipment manufacturers who overwhelmingly support their proposal, were well represented at the workshop, both on the official panels, and in the composition of the participants. An estimated 60-70% of the participants represented the interests of the Grand Alliance, video equipment manufacturers, consumer electronics manufacturers, the cable industry and others who supported the Grand Alliance at that time--the cable industry recently reversed their position in support of the standard, and now advocates a marketplace driven standard rather than an FCC mandated standard.

2.2.2. From the report section entitled: "The Role of Video in the NII"

"The Grand Alliance HDTV System is an effective solution for delivering high-quality, high-definition pictures and sound over a wide service area by terrestrial broadcast. The FCC's mandate to simulcast HDTV within the existing frequency allocations for television service requires low interference with existing NTSC service. This provision forces difficult tradeoffs among picture quality, sound quality, data rate, and HDTV coverage area, which must all be balanced in an overall HDTV system design. Entertainment television service further requires strict synchronization of video, audio and auxiliary data. The Grand Alliance system provides such capability and provides interoperability with other imaging media, e.g., motion picture film, NTSC television, and still images. While the Grand Alliance HDTV system will be useful in many NII applications beyond entertainment, there will clearly be a need for other advanced video standards. Applications in video production, medical, industrial, space, scientific, and defense industries may require higher resolution, different frame rates, or a different level of compression to meet quality or data rate requirements."

Comments:

At the time that the workshop took place the Grand Alliance system did not include any standard resolution television (SDTV) formats. These formats were added in July of 1995 and have never been subjected to the formal testing process used for the HDTV formats.

It is clear from this section of the report that the participants *did not* find the Grand Alliance system would support many of the applications envisioned for the NII; they found it to be optimized for the linear entertainment application for which the existing NTSC was designed.. To be fair, the participants emphasized that this system was designed first as an entertainment delivery system, in the image of the NTSC standard. Support for interoperability and NII applications was clearly an afterthought, brought about in large part by input from other stakeholder industries and the ACATS Working Party 4 Interoperability review. The general attitude at the workshop from proponents of the Grand Alliance system was that they had "bent over backwards" to provide support for interoperability...a position they still espouse today.

"Existing technologies, on which present compression techniques are based,

will be satisfactory for many NII applications. However, additional engineering will be required to develop a family of compression techniques to meet a wider range of quality and compression level requirements. The MPEG-2 standard, adopted by the Grand Alliance, could be a starting point for such a family of standards. As technology evolves and new methods are developed, equipment upgrades will be needed and should be considered in information appliance design. Today, cost-sensitive applications (i.e., consumer electronics) use specialized hardware that is not easily modified. For future information appliances, careful consideration should be given to including capabilities and required protocols to enable the transparent upgrade of functions, such as decompression or display, by downloading new software."

"Video standards on the NII should decouple programming, distribution, and appliances. Traditionally, each information supplier has had its own distribution system with appliances tailored to the medium. In the NII, digital video will be carried by a variety of distribution channels, and will be easily repackaged and stored. This permits video suppliers and users to use a common distribution infrastructure that provides competition across all markets. The distribution infrastructure must ride the technology curve, with continuous deployment and renewal. Video should be scaleable and extensible, e.g., encoded in a multi-resolution format that can be adapted to available resources. Achieving scalability without adversely affecting compression efficiency however represents an unsolved technical issue."

#### Comments:

It is clear from these paragraphs that the participants did not find the Grand Alliance proposal to be adequate in two important areas:

- Extensibility, to take advantage of rapid evolution in the underlying technology.
- Scalability, to provide multiple quality of service levels without the need for the most basic (affordable) receivers to be burdened with the cost of decoding the most demanding formats.

The issue of designing DTV as a modular, layered, scalable and extensible system versus a group of point standards optimized for the most demanding application--2 Mpixel

HDTV--has never been adequately resolved. Many of the comments to the 5th NPRM recommend that the DTV standard be built on a more aggressive "base layer" than is proposed in the Grand Alliance SDTV formats. The proposed SDTV formats are optimized for the existing interlaced production standards used for NTSC program origination. The "base layer" approach takes advantage of scalability--i.e. the use of augmentation signals to deliver higher resolution. This provides two significant advantages:

- "Base layer" receivers will *never* become obsolete, as extensibility will be facilitated through the optional augmentation layers.
- The "base layer" will provide a significantly higher quality of service level than the SDTV formats proposed by the Grand Alliance for only a small difference in cost to the consumer; the consumer would still have the option of buying a set-top decoder for existing NTSC receivers, or a low cost interlaced DTV receiver.

The workshop reported that "Achieving scalability without adversely affecting compression efficiency however represents an unsolved technical issue." The comments submitted by CICATS, William F. Schreiber, and Demografx clearly indicate that this problem is solvable, and bring into question whether it was really a problem in the first place. Far more important, however, is the fact that a solution to this problem *is not* necessary for deployment of a "base layer" standard. The research identified in the referenced comments indicates that the problem is already within the grasp of the research community and that solutions can be deployed via augmentation as the underlying technology evolves.

It is the opinion of PCUBE Labs that the "base layer" approach would accelerate the migration to DTV, as the difference in perceived quality in side-by-side comparisons of interlaced and progressive scan "base layer" receivers would be dramatic--essentially the same as comparing an existing NTSC receiver of the same picture height as the widescreen 525 line progressive scan system recently demonstrated to FCC Commissioners. If SDTV formats compatible with MPEG-2 MP@ML are allowed, there will be virtually no difference in perceived quality in side-by-side comparisons of interlaced and progressive scan SDTV receivers; this is due to the fact that vertical resolution is limited in MP@ML formats to prevent flicker on interlaced displays. Worse yet, the progressive scan receiver would exhibit aliasing artifacts with interlaced SDTV programs, unless an expensive de-interlacing facility were added to the proscan receiver. The additional cost for de-interlacing would be difficult to justify to achieve the same

picture quality as a lower cost interlaced receiver. De-interlacing would not be required if all of the content encoded by broadcasters for distribution were de-interlaced prior to encoding; a simple low pass filter could be used with interlaced displays to prevent flicker.

The Workshop report includes several summaries of the breakout discussions that are relevant to the proposed DTV standard.

### 2.2.3 Architectural Considerations, Modular Decomposition, and Interoperability

"The architecture discussion focused on the identification of "key long-lived reference points" in the conceptualization of the network..."

Note: The Workshop Report, available at the NIST web site, provides an extensive discussion of these reference points along with color diagrams.

"Rather than mandate a single standard at each reference point, industry should adopt a flexible architecture that assumes that the interfaces are constantly evolving and that most reference points will be realized by a variety of detailed standards. The principal requirement for NII interoperability is that a publicly documented interface be made available at each reference point. Market forces will then drive the implementation of converters and convergence of standards that facilitate the interoperability."

Comments:

Clearly the workshop participants recognized the need for an extensible modular architecture for DTV receivers and other "information appliances" that would interoperate with DTV broadcasts and information from other channels that carry digital information. The Commission should note that the ACATS PS/WP4 report came to the same conclusion, and that the original comments of PCUBE Labs to the 5th NPRM also suggested this approach.

The proposed ATSC standard is defined in terms of specific technology *winners* for each of the modular components of the system. These *winners* were determined in a closed

"bake-off," where the ACATS panel and the Grand Alliance determined which technologies would be considered for testing.

Several of the comments submitted to the FCC in response to the 5th NPRM indicate that:

- Other, possibly better, technologies were not considered;
- Superior technologies have been developed in the short period of time since the "bake-off" in 1993 and testing of the Grand Alliance System in 1994;
- A government regulatory process cannot keep up with the rapid pace of technological innovation characteristic of today's marketplace, and that which will exist as we move into the 21st Century.

In light of these facts, there are clear advantages to the Commission establishing a modular, layered, scalable and extensible framework for digital television, with a "base layer" standard to provide the desired level of certainty, and thus encourage rapid migration to digital television.

#### 2.2.4 Display Performance

"Display Performance addressed a contentious issue: is it possible to reconcile the demands for interlaced image capture with the superiority of progressive scan for display? There was no consensus on this question. There was anxiety that interlaced scanning may corrupt the whole advanced digital video system. It was recognized that one way to lower this anxiety is to assure that all film-sourced material (initially 60 - 70% of HDTV prime-time material) be transmitted in progressive scan. (This approach is supported by the Grand Alliance.) An additional requirement is that all HDTV material be transmitted at the full resolution of its particular format, that is any necessary filtering would be done at the receiver. Adopting these requirements would smooth the transition to higher quality systems."

"Display performance associated with various technologies was felt to be properly handled by market competition. Government can accelerate the rate of innovation by facilitating interface standards, funding pilot programs using video in education and health care, and establishing regulations and policy in such areas as the protection of intellectual property rights."



Comments:

The workshop was unable to reach consensus on this issue, as is evidenced by the inclusion of a majority and a minority report from the co-chairs of this discussion group.

This issue was not even resolved within the Grand Alliance. One member, Jae Lim of MIT, required that he be allowed to include a minority position statement, opposing interlace, when formation of the Grand Alliance was announced. Lim has consistently opposed the inclusion of interlaced formats in the DTV standard throughout the ACATS process.

This finding is consistent with the PS/WP4 Interoperability Review. Numerous comments to the 5th NPRM seek to eliminate interlace from the proposed DTV standard.

Clearly the Workshop report CANNOT be taken as an endorsement of the Grand Alliance system with respect to the inclusion of interlaced formats.

Finally, here are the actual recommendations from the Workshop Report:

#### 2.2.5 RECOMMENDATIONS

"The following recommendations, while not the result of a formal decision process, nevertheless represent statements that were strongly supported in the plenary and breakout discussions.

- \* The United States should move forward on HDTV as quickly as possible as it can be a powerful driving force for the development of NII applications. The Grand Alliance Proposal for HDTV is the best available alternative and is superior to any system which involves digitizing NTSC signals. Digital NTSC systems would propagate interlaced transmission and continue the division between entertainment television and the computer/communications technologies.

Comments:

The Grand Alliance system did not include SDTV formats at the time that this report was written. These formats were added in July of 1995 and have never been subjected to the same testing process as the HDTV formats.

The proposed ATSC standard cannot be considered "superior to any system which involves digitizing NTSC signals." The SDTV formats most likely to be used by local broadcasters do exactly what the report recommends against, in that they encode the same interlaced source imagery which now feeds the NTSC channels.

Allowing broadcasters to originate programming using MPEG-2 MP@ML encoding, will slightly reduce the start-up cost for small broadcasters and do little to encourage consumer adoption of the new standard. The incremental cost for the alternatives, however is small, and may encourage local broadcasters to step up to new opportunities to serve their markets, with video quality that is nearly double the resolution of the NTSC equipment that will be replaced:

- The cost for a broadcast quality system to de-interlace the video signals that feed NTSC transmitters is currently around \$20,000. It is likely that this capability could be incorporated in the design of a "base layer" encoder designed to a new MPEG-2 profile as proposed in Section 2.1.3 of these comments.
- According to engineers at Matsushita (doing business as Panasonic in the U.S.), the incremental cost of a new 480 line progressive scan camera, compatible with a "base layer" standard, would be about 10% higher than equivalent equipment for interlaced NTSC program origination. Matsushita and Ikegami currently offer such a camera as a standard product; the Matsushita camera is being used by Nippon Television Network (NTV) for development of Japan's new EDTV-2 service, and was recently demonstrated to FCC Commissioners. At the National Association of Broadcasters exhibition, held this past April, NTV and Matsushita demonstrated a complete 480 line production system, MPEG-2 compliant encoding and satellite transmission of the encoded programs.

" \* There will be continued controversy and disagreement over the desirability of an interlaced video format within the Grand Alliance System. Some believe that an all-progressive system is the only acceptable choice. The anxiety level would be reduced if the major broadcasting networks commit to broadcasting film-sourced material in unfiltered, progressive format. This approach is supported by the Grand Alliance, and there is an informal understanding that at least four

networks (ABC, NBC, CBS, and PBS) are planning to broadcast film in progressive formats."

Comments:

The Grand Alliance prototype system and most commercial MPEG-2 decoders automatically detect the use of 3/2 pulldown and encode only the original 24 Hz film frames. Unfortunately, any receiver that continues to operate at the 60 field or frame refresh rates, considered optimal for the proposed ATSC formats, will reintroduce 3/2 pull-up to display the 24 Hz film images. This practice will continue to introduce the motion judder artifacts which have plagued the presentation of film on NTSC displays--on large HDTV displays this judder will be more noticeable than on smaller, lower resolution displays.

While the major television networks will use the 24 Hz frame rate for encoding film source, it is not at all clear whether this material will be encoded at full vertical resolution. If film source is encoded at 1920 x 1080 resolution it may require vertical pre-filtering to reduce flicker on interlaced HDTV displays; this could reduce the vertical resolution below that provided by the progressive scan 1280 x 720 formats--i.e. approximately 600 lines of vertical resolution. It is unlikely that film would be presented at full vertical resolution if the source is encoded using one of the MP@ML based SDTV formats--these formats require vertical pre-filtering to eliminate flicker artifacts on interlaced displays. Virtually all MPEG-2 MP@ML encoded programming, delivered by DBS and cable systems today, is pre-filtered with respect to both horizontal and vertical resolution.

Most of the proposed Grand Alliance SDTV formats are supported in the MP@ML encoders being used for DBS, MMDS and digital cable services today; these encoders will be the most affordable to broadcasters. If the proposed ATSC standard is approved without modification, there is a high degree of likelihood that MP@ML encoders would be used by broadcasters for their initial DTV service, especially in smaller television markets where the cost of building a second DTV facility may equal or exceed the investment in the current NTSC facility. As discussed in the previous section, the cost to broadcasters to comply with an FCC regulation to de-interlace all source material would be very small.

Based on information included in comments to the 5th NPRM, acquisition equipment and encoders for the proposed progressive scan SDTV formats or the "base layer" format proposed by CICATS, represent only a small cost increase over existing interlaced acquisition equipment and MP@ML encoders--perhaps a 10% premium. This would place better DTV well within the reach of most local broadcasters, and hopefully lead to low cost versions for education and other NII applications in the near future.

Acquisition equipment and encoders for the proposed HDTV formats represent a major investment for local broadcasters, measured in millions of dollars. In many cases this investment would exceed the total market value of their NTSC facilities and license.

" \* There is a need for a long-term program involving government and industry to:

- facilitate interface standards,
- address intellectual property rights and information protection,
- fund research and development in interoperable systems, and
- establish pilot programs to apply advanced video technology in education, health care, and other areas of national importance."

Comments:

Mr. Birkmaier suggested at multiple times during the ACATS and ATSC proceedings the formation of a voluntary cross-industry association to deal with these issues. Comments to the 5th NPRM, filed with the FCC by PCUBE Labs, again suggested that such a group be formed, with an ex-officio member from the FCC to facilitate communications with the Commission.

PCUBE Labs again suggests to the Commission that they either appoint an appropriate panel or encourage industry to step up to this task.

" \* To serve the diverse needs of the NII, additional advanced digital video standards must be developed that complement the U.S. HDTV transmission standard. These should take into account and be interoperable with the U.S. HDTV standard."

Comments:

Clearly the workshop participants did not find the Grand Alliance system was adequate to handle NII requirements and interoperability with other digital communications infrastructures. The report recommends that "Video should be scaleable and extensible, e.g., encoded in a multi-resolution format that can be adapted to available resources."

Comments filed with the FCC in response to the 5th NPRM clearly indicate that the addition of 12 new SDTV formats, after the Workshop report was issued, have not resolved this issue.

" \* Standards should include both one- and two-way communications, provision for multicast video services, and internetworking cable, satellite, broadcast, common carrier, and packaged media. They should address the interconnection and interoperability of digital appliances and devices, digital networks and channels, software and programs, and third-party services. This will require identifying reference points (physical, management, and logical) and interfaces. Minimum service levels and staged criteria for interoperability and functionality should also be defined."

Comments:

These issues have never been adequately addressed by ACATS or the ATSC. The issue has been glossed over by statements that anything can be carried as ancillary data by the proposed MPEG-2 transport. Proponents of the proposed ATSC standard are vehement in their opposition to letting the marketplace determine the video formats that will be carried by the system, and the evolution of these formats. Yet they appear to be quite willing to let the marketplace deal with the establishment of new data broadcasting services using ancillary data. In fact, Mark Richer, Executive Director of the ATSC, requested Mr. Birkmaier's help in getting the computer industry to work within the ATSC process to develop voluntary data broadcasting standards.

The Grand Alliance and the ATSC continue to be inflexible with respect to modification of the proposed standard to enhance interoperability with other components of the

National Information Infrastructure. This is tantamount to saying that other stakeholders must bear the expense of interoperating with the Grand Alliance system.

The potential benefit, which might be derived by including support for interoperability in a government mandated DTV standard, is virtually ignored in the Grand Alliance system and the standard as documented by the ATSC.

" \* Industry is encouraged to demonstrate a comprehensive "multimedia" event with integration of transport modes (e.g., ATM and broadcast), the use of multiple delivery networks (including the Internet), and the integration of text, graphics, and video. The Grand Alliance is encouraged to provide coverage, transmission, and display of both live and filmed programs so that both progressive and interlaced modes will be demonstrated."

#### Comments:

The recommended demonstrations have never taken place, at least not with input from other stakeholders.

The Grand Alliance demonstrated the integration of text in DTV transmissions at the FCC En Banc hearing held in December of 1995.

- This presentation grossly misrepresented the capabilities of both the existing NTSC transmission infrastructure and the Grand Alliance system with respect to the available resolution for the presentation of text in each system. This demonstration understated the resolution capabilities of NTSC, and overstated the capabilities of the Grand Alliance system.
- An appendix to the comments of PCUBE Labs, submitted to the FCC in response to the 5th NPRM, included an article that Mr. Birkmaier wrote and published in Videography magazine. This article explained "display scalability," the underlying science of matching the resolution of a display system to the viewing conditions and application requirements; the analysis is applicable to all forms of information display. This article was based on an extensive analysis of this subject in the SMPTE Task Force Report on Digital Image Architecture; Mr. Birkmaier was a participant in the work of this Task Force in 1992 and acted as the author/editor of the report.

- One can only speculate as to whether the problems with the demonstration at the En Banc hearing were intentional, or simply resulted from a lack of familiarity of the computer-based image processing tools used to construct the demonstration. Mr. Birkmaier contacted the engineers at Sarnoff Labs who staged the demonstration for the Grand Alliance, to learn the exact procedure used to create the text displays; they never responded with the requested information, but did verify the computer application used to create the displays--Adobe Photoshop. PCUBE Labs attempted to duplicate their demonstration using this application and concluded that the text used in the HDTV demonstration was magnified by a factor of approximately 300%--i.e. what they claimed was 10 point text was actually about 30 point. This is about three times the size of the characters you are currently reading or a similar relationship to that which exists between

**HEADLINES** and body copy in newspapers and magazines.

The Grand Alliance demonstrated a prototype forward-and-store interactive commercial at NAB in 1995. This demonstration was presented using a standard multimedia computer, using off-the-shelf authoring tools and a progressive scan display. It was never tested using the proposed Grand Alliance transmission system.

- Numerous comments filed with the FCC in response to the 5th NPRM raise concerns about the viability of the proposed MPEG-2 transport for reliable delivery of the same kind of data files used in the interactive commercial demonstration.

2.2.6 With encouragement from Mr. Birkmaier and Mark Richer, a new Specialist Group on Data Broadcasting (T3/S13) has been formed under the auspices of the ATSC, with participation from the computer industry. The first item that will be tackled by this specialist group is to deal with the issue of reliable delivery of data files and executable code by the MPEG-2 transport.

The formation of this group is a clear indication of the willingness of other stakeholder industries to work within the ATSC to resolve issues these stakeholders raised in their comments to the 5th NPRM. It remains to be seen, however, if the ATSC process is sufficiently flexible to allow for consensus on issues that were identified as early as 1990 and debated ever since. For example, the ground rules established for the new specialist group preclude it from suggesting modifications to the proposed ATSC standard--whatever is done must be *layered* onto the system as documented by the ATSC.

### **2.3 Resolution and Display Scalability**

One of the most compelling arguments used by both sides in this debate about the future of television broadcasting in the United States, relates to the engine that is driving the revolution in digital communications...Moore's Law.

From the start, the chip industry has possessed a wonderful trait that Gordon Moore, a physicist who co-founded and is now chairman of Intel, identified in a 1965 magazine article. He noticed that manufacturers had been able to double the number of circuits on a chip every year, causing an exponential leap in power each time. That leap in power meant the cost per circuit was cut in half each time. This observation became known as "Moore's Law" and has been a goal for the chip engineers to sustain. Around 1976 or 1977, the doubling slowed to every 18 months, and some experts say it has recently slowed again. With current design, testing and manufacturing techniques, most engineers believe the doubling of circuitry can continue at least another decade.

On August 8, at the SIGGRAPH Conference in New Orleans, the issues discussed in these and other comments to the 5th NPRM were debated once again in a panel organized by Gary Demos of Demografx. The other participants included Alvy Ray Smith of Microsoft, Mark Richer of the ATSC, Glenn Reitmeier of Sarnoff Labs (representing the Grand Alliance), and Craig Birkmaier of PCUBE Labs. Reitmeier, Smith and Birkmaier all invoked Moore's Law to support their positions.

Smith suggested that Moore's Law makes it virtually impossible to predict where technology will take us in a few short years; he pointed to the fact that when the ATV process was initiated in 1987 television industry experts said it was impossible to squeeze HDTV into a 6 MHz television channel. A few years later the acronym for this standard changed from ATV to DTV; and in 1995 the target changed again from HDTV to HDTV & SDTV. Explaining why the computer industry was late coming to the table, Smith pointed out that in 1987 a PC was useful for little more than word processing and spread sheets. Thanks to Smith's pioneering work in computer animation, PC's are now used to render computer generated imagery (CGI) for motion pictures--eight of Hollywood's top ten movies this summer involve extensive use of CGI.



Birkmaier suggested that Moore's Law provides a logical framework upon which we can *layer* new capabilities as the engine delivers ever increasing performance to fuel new applications and services. He pointed out that virtually every industry that has been powered by this engine has been built from the ground up, evolving in response to the marketplace. And he pointed to a gaping hole in the international MPEG-2 standards, lying between the backward looking SDTV formats and the long term target of HDTV. Birkmaier suggested that these targets were established by manufacturers with vested interests to protect...manufacturers who have suppressed efforts to develop the logical, affordable, high quality television formats that lie between SDTV and HDTV.

Reitmeier suggested that DTV will not become a significant factor for consumers until 2003--stations will have three years to apply for the licenses that the Commission plans to begin issuing next year, and another three years to construct a facility and begin DTV programming. In those years, Reitmeier suggested, the cost of memory and other components of an HDTV receiver will be driven down by the Moore's Law engine, bringing an HDTV receiver within the reach of any consumer.

It is easy to comprehend that Moore's law will quickly bring incredible processing power to bear on the problem of delivering HDTV quality encoding and decoding hardware. Clearly the digital compression and transmission components which lie between the acquisition and the display of images will not be the throttle on digital television...they are the engine.

The acquisition components of a digital television system have also seen significant advancements over the years that this standard has been debated. Just a few years ago, television equipment manufacturers told us that a high frame rate progressive scan HDTV camera was a distant target. Yet the Commission was recently treated to a demonstration of a 1280 x 720 @ 60 frame per second progressive scan camera, based on an image sensor developed by Polaroid. There are many components of an HDTV production facility that resist the power of the Moore's Law engine, but the asymmetrical aspect of the few-to-many broadcast equation allows for larger investments in the broadcast plant. Furthermore, the inherent flexibility of a scalable, extensible digital television system allows local broadcasters to choose an appropriate quality of service level, matched to the economic realities of their markets.